

Ecology of Children's Growth: An Example from Transitional Populations of the Brazilian Amazon

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Received: 18 October 2005 / Accepted: 10 August 2006 /

Published online: 15 November 2006

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Abstract The intense environmental and social changes taking place in Amazonia make this a key area for health studies of populations transitioning to a cosmopolitan lifestyle and market economy. Caboclos are among those populations. They comprise the majority of rural Brazilian Amazon peoples. At present there is limited information about their patterns of growth and health. In this paper, anthropometric data on Caboclo children from three groups living in different environments are presented and discussed within a bioanthropological framework. Caxiuanã, Aracampina, and Santana have a combined population of 1,069 people. Caxiuanã relies more on subsistence activities for survival and Santana more on commerce, while Aracampina uses both subsistence strategies. Compared to US children, Caboclo are generally shorter and lighter in all age groups. However, their weight-for-height is above the 50th percentile. In relation to skinfolds, age groups 0–2, 6–8, and 9–11 years present statistically significant differences among the three communities. Caxiuanã children have the smallest and Aracampina children have the largest skinfolds. While seasonal and environmental differences may account for some of the observed variation in growth and fatness patterns, socioeconomic factors also play a key role in the trends observed. Thus, an ecological model provides the best framework for explaining these findings. Caxiuanã children are small and thin as a result of their combined poor environment and limited access to cash, western goods, and health care. Aracampina and Santana's fuller access to such socioeconomic influences and richer ecology results in taller and fatter children. Understanding similar interactions between ecology and social factors will be fundamental to developing sustainable health initiatives among rural Amazonian populations.

Keywords Caboclos · Health · Stunting · Pará · Rural populations

A previous version of this paper was presented at the XV ICAES, Florence, Italy, 2003.

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Introduction

Rural populations of the Brazilian Amazon are often called Caboclos [26, 44, 49, 50]. They resulted from admixture among Portuguese colonizers, escaped or freed African slaves, and native South Amerindians living along the Amazon River and its tributaries in Brazil. These populations have increased in numbers and in importance in the Amazon since the rubber boom of the late 19th century [7, 33, 49, 50]. Today, Caboclos comprise the majority of the riverine peasant populations in Northern Brazil [44]. Nevertheless, little is yet known about many aspects of their life, health, and modes of interaction with the environment.

Research has established that health and disease are associated closely with adequate levels of nutrition as availability and access to food are major determinants of individual survival [20, 40]. During childhood, humans are extremely sensitive to nutritional deficiencies and related diseases, as throughout the growth process, all biological systems require a constant and regular inflow of nutrients to develop properly [5, 11]. The consequences of nutritional deficits occurring during growth resonate throughout an individual's entire life [4, 6, 9, 12, 32].

Several attempts have been made to describe the general nutritional status and growth characteristics of Brazil's children and adults [8, 21, 22, 29, 30]. In general, research in the country has concentrated on areas with higher population densities, such as São Paulo, Rio de Janeiro, Belo Horizonte, and the Northeastern states. No extensive and reliable reports exist on health and growth characteristics of children in rural areas of the Amazon basin [23, 45]. In addition, there are some bioanthropological studies focusing on the health and/or growth characteristics of Caboclo groups [1, 35, 38, 42–44, 46–48].

In this paper, we characterize the growth and nutritional situation of Caboclo children and examine the influences of sex, age, and place of residency on these measures. The focus is on groups living in three areas in the state of Pará, Brazil, with different ecosystems, subsistence strategies, and degrees of contact with the market economy. In general, it is hypothesized that the level of involvement of Caboclo populations with market economy is associated with negative influences on the patterns of health and growth of their children. This hypothesis is tested using data collected in the three Caboclo groups during the rainy and the dry seasons, between 1996 and 1997.

Samples

The three groups studied, include approximately 1,069 people, of whom approximately 40% are children 11 years old or younger. Although the groups studied live in different environments, leading to somewhat different lifestyles, they share most of their traditions, customs, and culture, and a similar genetic background, composed of European, Amerindian, and African ancestors.

Caxiuanã

Caxiuanã ($N=212$) is the least studied population. This group lives in the Caxiuanã National Forest ($1^{\circ}42'30''$ S, $51^{\circ}31'45''$ W) a protected area in the heart of the rainforest. The nearest town to Caxiuanã is Portel, 9 h west by motorboat [27]. The group lives in an area of relatively acidic black waters in the Caxiuanã bay. Their subsistence is mainly based on manioc (*Manihot esculenta*), bananas (*Musa* sp.), and tropical fruit, with fish and hunted

game, and extraction of natural products such as Brazil nuts (*Bertoletia excelsia*). Occasionally, the diet is complemented with a variety of packaged products such as pasta, crackers, canned meats, rice, beans, and sometimes free-range chicken, duck, or pig. With the exception of an increased consumption of açai (*Euterpe olleracea*) during the dry season, there are no major changes in the diet of Caxiuanã dwellers from the wet to the dry season. Caxiuanã reflects a more traditional lifestyle because its population has few and limited interactions with local markets [44, 45].

Aracampina and Santana

The other two populations in the study are situated on Ituqui Island, Santarém county, Pará (20°30' S, 54° E 30' W). Ituqui is located 3 h downstream by boat from Santarém, in the Tapajós river, a white water ecosystem. Because the Island's communities are more fully integrated into the local market economy, they represent a more transitional population, although as rural groups, they are not subject to the additional stressors of an urban environment.

Aracampina ($N=380$) is the community most affected by seasonality. The entire village is flooded during the wet season [24, 28]. Subsistence resources come mainly from fishing, subsistence agriculture, and a few retirement pensions. This population's diet is based on manioc flour, fish, and rice, complemented with chicken, pork or game and, more rarely, beef. In the wet season, diet is more varied and includes packaged products such as crackers, tinned foods, powdered milk, and pasta [36, 44].

Santana ($N=477$) is the most westernized of the groups due to its population size, infrastructure, and the intense contact and commerce it maintains with Santarém. Subsistence activities in Santana include agriculture, fishing, commerce, retirement pensions, and a few white-collar jobs in the school and the health post. In the dry season, diet in Santana is based on fish, manioc flour, and rice with other products such as beef, game meat, chicken, beans, and pasta added occasionally. As in Aracampina, during the wet season more packaged products such as powdered milk and chocolate, crackers, pasta, and tinned foods are added to meals, which are also complemented with seasonal fruits. Coffee with sugar is consumed regularly in all three groups [36, 44].

Materials and Methods

Data to evaluate physical growth, nutritional situation, and body habitus were collected following internationally accepted standard procedures [13, 19, 51]. All data were collected twice, once in the dry season, and again in the wet season.

The six anthropometric measurements used in this study (height, weight, upper arm circumference, triceps, subscapular and suprailiac skinfolds) are the basic set recommended and used by most authors in the field [13, 15]. All measurements were collected by the first author to avoid inter-observer errors. Over 85% of the children ages 0–11 years of the three populations were measured in both seasons.

Body composition was calculated using the following information from the anthropometric data [13]:

Sum of skinfolds (Sumskfd) = triceps + subscapular + supra iliac

Arm fat index (AFI) = $(\text{UAFA}/\text{TUAA}) \times 100$

Upper arm fat area (UAFA) = $\text{TUAA} - \text{UAMA}$

Total upper arm area (TUAA) = upper arm circumference²/(4 × π)

Upper arm muscle area (UAMA) = [upper arm circ – (triceps × π)]²/(4 × π)

To facilitate statistical analysis, comparison of height-for-age, weight-for-age, and weight-for-height with international reference data [37] was conducted with Aracampina and Santana combined (then called Ituqui), and Caxiuanã. Further analyses were conducted with the three groups separated. Methods of analysis included *Z* scores, with a cut-off point of -2 *Z* scores for short and low-weight individuals [31, 52], *t* tests, and multiple regression.

Results

There are no statistically significant differences between boy's and girl's heights, weights, skinfolds, upper arm fat area (UAFA), upper arm muscle area (UAMA), or arm fat index (AFI) by age group (data not shown). In the dry season, children from Caxiuanã are shorter and lighter than children from Aracampina and Santana in all age groups. In the wet season the trend is more complex. Caxiuanã children are shorter than Aracampina and Santana children, but at ages 0–2 years they are heavier than Santana children, and at ages 3–5 and 6–8 years they are heavier than Aracampina's children. In the dry season, arm circumferences of Caxiuanã children are smaller than Aracampina's and Santana's in all age groups, except in the 6–8 years group. In the wet season, Caxiuanã children have larger arm circumferences than Aracampina's and Santana's in age groups 0–2 and 6–8 years, but not at ages 3–5 and 9–11 years. Aracampina children are heavier and have larger arm circumferences than Santana's at ages 0–2 in the wet season, but the trend is not consistent in the dry season or in other age groups.

Statistically, there are no significant differences in the percent of children per-*Z*-score category between Caxiuanã and the two groups from Ituqui (Table 1). Because 64.5% of the children were measured twice, the effect of season on their growth can be evaluated using *Z* scores. As there are no statistically significant differences in mean *Z* scores between boys and girls in any community, the sexes were combined and then divided by age groups for further analysis.

Table 1 Percent distribution of children (0–11 years old) by season of the year, according to *Z* scores of height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ), sexes combined.

Caxiuanã				Ituqui			
<i>Z</i> score	≤−2	−1.99–0	>0	≤−2	−1.99–0	>0	<i>p</i> value
Dry season							
HAZ	79.6	18.7	1.7	72.1	26.9	1.0	0.11
WAZ	34.8	62.1	3.1	26.6	66.8	6.6	0.58
WHZ	0.0	26.6	73.4	1.4	36.4	62.2	0.50
Wet season							
HAZ	80.3	19.7	0.0	72.3	26.1	1.6	0.16
WAZ	31.1	66.2	2.7	23.8	69.6	6.6	0.28
WHZ	0.0	19.3	80.7	2.1	29.9	68.0	0.19

P values (based on *t* test) for differences between groups

Mean combined height-for-age Z scores in Caxiuanã do not change significantly between the wet and the dry seasons ($p=0.14$), but both weight-for-age and weight-for-height Z scores are statistically different between the dry and wet seasons ($p=0.05$, $p=0.02$, respectively; Table 2, Part I). In Ituqui, average height-for-age and weight-for-age Z scores differ significantly between wet and dry seasons ($p<0.01$, $p=0.01$; Table 2, Part I). When boys and girls are separated, a slightly different picture emerges with mean Z scores in the dry season lower and closer to zero, than in the wet season in all groups (Table 2, Part II). The pairwise comparison of Z scores for Caxiuanã shows a statistically significant difference in height-for-age between the dry and wet seasons in boys ($p=0.02$).

In Ituqui, height-for-age and weight-for-height of boys are significantly different between the seasons ($p=0.01$, and $p=0.02$) and so is height-for-age of girls ($p=0.02$; Table 2, Part II). Mean Z scores for height-for-age, weight-for-age, and weight-for-height in the two seasons were compared across populations. Overall, Caxiuanã children have higher

Table 2 Means, standard deviations of height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) Z scores of children ages 0–11, by group. P values (based on paired t tests) for differences between seasons with sexes combined (part I), with sexes separated (part II), and among groups per season of the year (part III).

Part I		Caxiuanã				Ituqui			
		<i>N</i>	Mean	SD	<i>P</i>	<i>N</i>	Mean	SD	<i>P</i>
Pair 1	HAZ (dry season)	56	−3.02	1.19	0.14	160	−2.61	0.96	0.00
	HAZ (wet season)	56	−3.12	1.37		160	−2.31	1.57	
Pair 2	WAZ (dry season)	61	−1.55	0.83	0.05	170	−1.49	0.86	0.01
	WAZ (wet season)	61	−1.67	0.93		170	−1.39	0.80	
Pair 3	WHZ (dry season)	48	0.64	0.71	0.02	141	0.31	0.99	0.49
	WHZ (wet season)	48	0.40	0.78		141	0.36	0.80	
Part II		Caxiuanã				Ituqui			
Males		<i>N</i>	Mean	SD	<i>P</i>	<i>N</i>	Mean	SD	<i>P</i>
Pair 1	HAZ (dry season)	30	−3.07	1.36	0.02	83	−2.67	0.91	0.01
	HAZ (wet season)	30	−3.24	1.41		83	−2.56	0.93	
Pair 2	WAZ (dry season)	32	−1.57	0.85	0.11	89	−1.45	0.87	0.09
	WAZ (wet season)	32	−1.71	1.03		89	−1.32	0.79	
Pair 3	WHZ (dry season)	27	0.63	0.66	0.15	81	0.49	0.88	0.02
	WHZ (wet season)	27	0.43	0.80		81	0.64	0.78	
Females		<i>N</i>	Mean	SD	<i>P</i>	<i>N</i>	Mean	SD	<i>P</i>
Pair 1	HAZ (dry season)	26	−2.96	1.00	0.81	77	−2.56	1.01	0.02
	HAZ (wet season)	26	−2.99	1.32		77	−2.04	2.03	
Pair 2	WAZ (dry season)	29	−1.52	0.82	0.26	81	−1.56	0.85	0.07
	WAZ (wet season)	29	−1.63	0.82		81	−1.47	0.82	
Pair 3	WHZ (dry season)	21	0.65	0.79	0.07	60	0.12	1.09	0.58
	WHZ (wet season)	21	0.36	0.77		60	0.17	0.88	
Part III		Caxiuanã				Ituqui			
			Mean	SD			Mean	SD	<i>P</i>
	HAZ (dry season)		−1.10	4.57			−0.10	5.07	0.11
	HAZ (wet season)		−0.18	5.68			0.80	5.57	0.16
	WAZ (dry season)		−0.53	3.35			0.47	4.39	0.05
	WAZ (wet season)		0.51	4.62			1.16	4.82	0.28
	WHZ (dry season)		2.40	4.07			2.77	4.33	0.50
	WHZ (wet season)		2.78	4.21			3.53	4.60	0.19

Table 3 Means, standard deviations, and *p* values (based on paired *t* tests) for comparisons of height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) *Z* scores of children ages 0–11 from Caxiuanã, Aracampina, and Santana between seasons, by age group with males and females combined.

Age Group	Caxiuanã				Aracampina				Santana			
	<i>N</i>	Mean	SD	<i>p</i>	<i>N</i>	Mean	SD	<i>p</i>	<i>N</i>	Mean	SD	<i>p</i>
0–2 years												
Pair 1 HAZ (dry season)	12	−2.90	1.37	0.90	12	−2.92	1.37	0.90	23	−3.17	1.24	0.37
HAZ (wet season)	12	−2.95	1.34		12	−2.95	1.34		23	−2.91	1.05	
Pair 2 WAZ (dry season)	16	−1.54	1.08	0.89	15	−1.68	0.97	0.93	31	−1.57	1.21	0.96
WAZ (wet season)	16	−1.57	0.98		15	−1.66	0.95		31	−1.57	1.06	
Pair 3 WHZ (dry season)	12	0.18	0.84	0.93	12	0.16	0.84	0.92	23	0.18	1.50	0.70
WHZ (wet season)	12	0.21	0.90		12	0.19	0.90		23	0.17	1.09	
3–5 years												
Pair 1 HAZ (dry season)	16	−3.80	1.71	0.28	16	−3.89	1.71	0.26	34	−2.79	0.92	0.00
HAZ (wet season)	16	−3.50	1.10		16	−3.71	1.39		34	−2.57	1.04	
Pair 2 WAZ (dry season)	17	−2.18	1.44	0.04	17	−2.10	1.04	0.04	36	−1.61	0.94	0.14
WAZ (wet season)	17	−1.94	0.87		17	−1.84	0.97		36	−1.51	0.87	
Pair 3 WHZ (dry season)	16	0.56	0.68	1.32	16	0.26	0.86	1.31	34	0.13	0.84	0.88
WHZ (wet season)	16	0.49	0.60		16	0.59	0.60		34	0.12	0.78	
6–8 years												
Pair 1 HAZ (dry season)	17	−2.70	0.85	0.07	17	−2.69	0.88	0.06	53	−2.43	0.86	0.06
HAZ (wet season)	17	−2.60	0.76		17	−2.62	0.76		53	−2.33	0.75	
Pair 2 WAZ (dry season)	17	−1.45	0.78	0.00	17	−1.40	0.73	0.00	53	−1.44	0.69	0.15
WAZ (wet season)	17	−1.35	0.57		17	−1.22	0.65		53	−1.35	0.64	
Pair 3 WHZ (dry season)	17	0.60	0.85	0.00	17	0.60	0.65	0.00	53	0.33	0.86	0.33
WHZ (wet season)	17	0.95	0.35		17	0.93	0.53		53	0.44	0.74	
9–11 years												
Pair 1 HAZ (dry season)	11	−2.88	1.11	0.22	3	−3.18	1.65	0.67	48	−2.43	0.83	0.00
HAZ (wet season)	11	−2.72	0.96		3	−3.15	1.74		48	−2.29	0.78	
Pair 2 WAZ (dry season)	11	−1.63	0.61	0.37	3	−1.54	1.09	0.77	48	−1.40	0.70	0.00
WAZ (wet season)	11	−1.57	0.45		3	−1.59	0.82		48	−1.24	0.72	
Pair 3 WHZ (dry season)	3	0.96	0.44	0.94	3	0.96	0.44	0.94	31	0.65	0.82	0.03
WHZ (wet season)	3	0.99	0.48		3	0.97	0.46		31	0.82	0.84	

negative mean *Z* scores than Ituqui children for all three markers. However, mean height-for-age *Z* scores do not differ statistically between Caxiuanã and Ituqui in either season. Mean weight-for-age *Z* scores are significantly different in the dry ($p=0.05$), but not in the wet season ($p=0.28$), and weight-for-height *Z* score differences between groups are not significantly different in any of the seasons (Table 2, Part III).

When the mean *Z* scores of the three communities, by age group, are compared between the dry and the wet seasons using paired *t* tests, few differences emerge. Generally, mean *Z* scores in the dry season are lower than in the wet season for height-for-age, weight-for-age, and weight-for-height, but most of the differences do not reach statistically significant levels (Table 3). Differences are statistically significant in weight-for-age ($p<0.001$) and weight-for-height in Caxiuanã ($p<0.001$), and Aracampina ($p<0.001$). In both cases, a higher negative mean *Z* score is observed in weight-for-age in the dry season, and a higher positive mean *Z* score is observed in weight-for-height in the wet season (Table 3). In the 9–11 age group, differences between seasons are statistically significant in height-for-age, weight-for-age, and weight-for-height, but only in Santana ($p<0.001$, $p>0.001$, $p=0.03$,

respectively). Height-for-age and weight-for-age present a higher mean negative Z score in the dry season, and a higher positive mean Z score in weight-for-height in the wet season (Table 3).

When the children of the three populations are combined and analyzed through multiple regression of height, weight, and anthropometric indices per age group, it is shown that in the youngest age group (0–2 years) values are not associated with place of residency or sex. But in the older age groups (3–5, 6–8, 9–11 years) some relationships appear (Table 4). Sex is strongly associated with AFI in the age groups 3–5 years ($p < 0.001$, $p < 0.001$, dry and wet seasons, respectively), 6–8 years ($p = 0.02$, $p < 0.001$, dry and wet seasons, respectively), and 9–11 years ($p = 0.02$, $p < 0.001$, dry and wet seasons, respectively), the boys' values being always higher than the girls'. Sum of skinfolds is also strongly associated with sex in the age groups 3–5 years ($p = 0.01$, $p = 0.01$, dry and wet seasons, respectively), 6–8 years ($p < 0.001$, $p < 0.001$, dry and wet seasons, respectively), and 9–11 years ($p = 0.05$, $p < 0.001$, dry and wet seasons, respectively), also with boy's values higher than girls'.

Additionally, UAFA is strongly associated with sex in the 3–5 ($p = 0.02$), and 6–8 age groups ($p = 0.01$) in the wet season, with boy's values higher than girls'. Finally, UAMA is associated with sex in the age groups 3–5 years in the wet season ($p = 0.01$), 6–8 years in the dry season ($p = 0.02$), and 9–11 years in both seasons ($p = 0.01$, $p < 0.001$, dry and wet seasons, respectively; Table 4). In the case of UAMA, girls' mean values are overall higher than boys'.

Place of residency has a strong influence on height of the 3–5 age group ($p = 0.02$, dry season), with the Caxiuanã children being, on average, 5 cm shorter than the children from Ituqui (Table 4). In the 9–11 years, the children from Caxiuanã are, on average, 3 cm shorter than the Aracampina and 5 cm shorter than the Santana children, in the dry and wet seasons ($p = 0.01$, $p = 0.03$, respectively). In relation to weight, the 9–11 age group children from Caxiuanã are significantly lighter than the Santana children in both seasons ($p = 0.04$, $p = 0.04$). In relation to AFI, the 6–8 and 9–11 age groups from Caxiuanã present significantly lower mean values than the Ituqui groups, in the dry season ($p = 0.01$, $p < 0.001$, respectively). The mean sum of skinfolds of the 6–8 and 9–11 age groups are higher in Ituqui than in Caxiuanã in the dry season ($p < 0.001$, $p < 0.001$). The mean UAFA of the 9–11 age group from both Ituqui communities are significantly higher than the mean of the Caxiuanã children in the dry season ($p = 0.03$); and the mean UAMA values of the 6–8 and 9–11 age groups from Caxiuanã are higher than those from Ituqui in the dry season ($p = 0.02$, $p = 0.03$, respectively; Table 4).

Discussion

When compared to the NCHS/WHO reference data, children from Caxiuanã, Aracampina, and Santana are shorter and lighter than the 50th percentile of the reference, while their weight-for-height is above the 50th percentile. The same trends are present in both seasons of the year.

In Brazil, there are no general updated growth charts based on the national population. However, some research exists which allows comparisons with growth characteristics of children from different parts of the country and also from other countries.

Engstrom and Anjos [10], examining childhood stunting and their mother's nutritional status in a general sample of the Brazilian population, observed 14.4% of stunting (15.9% boys and 12.9% girls), and a strong association between mothers' educational

Table 4 Multiple linear regression model with height, weight, arm fat index (AFI), sum of skinfolds (Sumskfd), upper arm fat area (UAFA), and upper arm muscle area (UAMA) of children (0–11 years old), per age group, as dependent variables, and sex and community (place) as independent variables.

Age group (years)	Variable	<i>F</i>	<i>p</i>	Age group (years)	Variable	<i>F</i>	<i>p</i>
Sex/Height				Place/Height			
0–2	Dry season	1.61	0.21	0–2	Dry season	0.42	0.52
	Wet season	0.01	0.91		Wet season	1.15	0.29
3–5	Dry season	0.50	0.48	3–5	Dry season	5.21	0.02
	Wet season	1.82	0.18		Wet season	3.25	0.78
6–8	Dry season	0.35	0.55	6–8	Dry season	2.39	0.12
	Wet season	0.61	0.43		Wet season	2.07	0.15
9–11	Dry season	0.00	0.92	9–11	Dry season	6.17	0.01
	Wet season	0.48	0.49		Wet season	4.56	0.03
Sex/Weight				Place/Weight			
0–2	Dry season	1.34	0.25	0–2	Dry season	0.14	0.70
	Wet season	5.73	0.02		Wet season	0.04	0.83
3–5	Dry season	0.24	0.62	3–5	Dry season	2.40	0.12
	Wet season	0.03	0.85		Wet season	0.45	0.50
6–8	Dry season	3.35	0.07	6–8	Dry season	0.79	0.37
	Wet season	2.97	0.08		Wet season	0.10	0.74
9–11	Dry season	0.84	0.36	9–11	Dry season	4.22	0.04
	Wet season	0.00	0.99		Wet season	4.06	0.04
Sex/AFI				Place/AFI			
0–2	Dry season	2.78	0.10	0–2	Dry season	0.48	0.49
	Wet season	0.00	0.95		Wet season	0.01	0.89
3–5	Dry season	9.36	0.00	3–5	Dry season	2.92	0.09
	Wet season	10.56	0.00		Wet season	0.05	0.82
6–8	Dry season	5.33	0.02	6–8	Dry season	6.53	0.01
	Wet season	13.98	0.00		Wet season	1.55	0.21
9–11	Dry season	5.22	0.02	9–11	Dry season	8.57	0.00
	Wet season	9.66	0.00		Wet season	0.25	0.61
Sex/Sumskfd				Place/Sumskfd			
0–2	Dry season	3.29	0.07	0–2	Dry season	0.25	0.62
	Wet season	0.05	0.81		Wet season	2.35	0.13
3–5	Dry season	6.40	0.01	3–5	Dry season	3.70	0.06
	Wet season	6.79	0.01		Wet season	1.27	0.26
6–8	Dry season	7.72	0.00	6–8	Dry season	12.4	0.00
	Wet season	7.38	0.00		Wet season	2.91	0.09
9–11	Dry season	3.88	0.05	9–11	Dry season	9.12	0.00
	Wet season	10.50	0.00		Wet season	2.45	0.12
Sex/UAFA				Place/UAFA			
0–2	Dry season	0.23	0.62	0–2	Dry season	0.16	0.68
	Wet season	0.96	0.33		Wet season	0.13	0.72
3–5	Dry season	2.44	0.12	3–5	Dry season	0.41	0.52
	Wet season	5.20	0.02		Wet season	0.07	0.78
6–8	Dry season	1.79	0.18	6–8	Dry season	2.31	0.13
	Wet season	6.20	0.01		Wet season	0.22	0.63
9–11	Dry season	1.78	0.18	9–11	Dry season	4.63	0.03
	Wet season	2.81	0.10		Wet season	0.98	0.32
Sex/UAMA				Place/UAMA			
0–2	Dry season	3.69	0.06	0–2	Dry season	0.24	0.62
	Wet season	2.66	0.11		Wet season	0.08	0.77
3–5	Dry season	3.27	0.07	3–5	Dry season	1.79	0.18

Table 4 (continued)

Age group (years)	Variable	<i>F</i>	<i>p</i>	Age group (years)	Variable	<i>F</i>	<i>p</i>
6–8	Wet season	6.60	0.01	6–8	Wet season	0.13	0.71
	Dry season	5.01	0.02		Dry season	5.16	0.02
9–11	Wet season	2.92	0.09	9–11	Wet season	1.36	0.24
	Dry season	6.52	0.01		Dry season	4.54	0.03
	Wet season	9.49	0.00		Wet season	0.54	0.46

level and stunting. In a case-control study of 264 children attending first grade in Osasco city, São Paulo state, Lei et al. [25] identified strong associations of mother's level of schooling, environmental sanitation, and family income with stunting. No direct relationships between education or income and nutritional status were observed among the three study groups [44]. However, it was observed that Caboclo, with more access to educational and economic resources (Santana), present lower disease rates and a more varied diet. In addition, the children from the two Ituqui groups are generally taller and heavier than Caxiuanã children, the group with lower economic resources.

In urban areas of Rio de Janeiro, Anjos et al. [3] reported on growth, AFI, and UAMA of children of different SES. Nutritional status and SES were significantly correlated. Similar to data reported here, age-specific patterns (curves) of AFI and UAMA were similar among boys and girls. Additionally, UAMA of boys were consistently higher than girls, independent of SES, while undernutrition in the low SES group was 6.25% for stunting, and 3.52% for wasting, *versus* 0.5% for stunting and no wasted child in the higher SES group [3]. In contrast to Caxiuanã, the urban sample examined by Anjos et al., [3] received daily dietary supplementation in the form of school meals, and likely had more access to health care. The overall percents of both stunting and wasting in Rio de Janeiro and Osasco children were lower than those observed among the Caboclos.

Alencar et al. [2] examined 283 children (0–5 years old) from rural and urban areas in Amazonas state, and found 31.1% with low height-for-age, but low weight-for-height was observed in only 4.2%. Among urban children, undernutrition reached 41.7%, but in rural areas the incidence was only 25.6%. They further report that children were particularly affected by undernutrition in their first year of life, possibly associated with weaning, a common finding [11, 33]. According to Alencar et al. [2], although low weight-for-height was more prevalent in children 1 year old or less, low height-for-age was more prevalent in older children. In addition, they reviewed other data suggesting variable prevalence of undernutrition in urban areas of Amazonas, such as São Gabriel da Cachoeira (35.6%) and Novo Airão (49%). Overall, rates of undernutrition in urban areas are lower than are observed in the Caboclo.

Giugliano et al. [16] investigated 69 children between 7 and 11 years of age of low SES in the city of Manaus; 83% of them were below the 50th percentile of height-for-age and 16.6% were below the 50th percentile of weight-for-height. They concluded that 13% of the children in their sample were both stunted and wasted according to NCHS/WHO references. Distinct from other studies in urban areas, results for Manaus are consistent with the Caboclo data reported here for height-for-age, but incidence of low weight-for-height is higher in Manaus than in the Caboclo.

Murrieta et al. [36], reporting data from 1994 from Caboclo children in two rural communities on Ituqui Island, found only 2.1% of their sample of 232 children ages 0 to 10 years to present low *Z* scores of weight-for-height, consistent with findings from this

research. Of the sample of Murrieta et al. [36], 87.1% was below the 50th percentile on height-for-age; the results reported here show a lower prevalence of stunting in all three Caboclo populations. Consistent with data reported here, Murrieta et al. [36] found no significant differences in the distribution of Z scores between boys and girls. Data from girls of low-income families in the peri-urban region of Santarém [42] also showed nutritional patterns comparable to those of Aracampina and Santana, and similarly high rates of anemia, skin diseases, and tooth decay [44]. On studies of rural children along the Solimões river, a clear water ecosystem, Giugliano et al. [17] reported 54.7% of them to be undernourished according to NCHS/WHO reference. In the Rio Negro region, a black water ecosystem, the prevalence of undernourished children was 63.3% [18]. These prevalence rates are lower than those observed in Caxiuanã, Santana, and Aracampina.

In a general review of physical growth and nutritional status of indigenous South Amerindian populations, Santos [41] showed that overall Brazilian samples are short and light for their age compared to NCHS/WHO references. However, like the Caboclo, these Indians maintain their body proportions, as evaluated by weight-for-height. Santos reported rates of stunting in children as low as 23.7% among the Siona-Secoya of Ecuador to as high as 75.0% among the Chachi. On the other hand, low weight-for-height ranged from 0.8% among the Suruí, Gavião, and Zoró of Brazil, to 10% among the Shipibo of Peru. Weight-for-height among the populations sampled here are closer to those of Suruí, Gavião, and Zoró than to Shipibo. In both Caxiuanã and Ituí, height-for-age Z scores are farther from the 50th percentile than weight-for-age Z scores, suggesting that stunting is more severe than wasting in these populations. A pattern similar to that observed among South Amerindians. Additionally, no cases of marasmus or kwashiorkor were observed in the Ituí populations, and the only case of PEM was a 4-year-old girl from Caxiuanã.

The Caboclo groups from Ituí Island are undergoing considerable levels of socio-economic modification in their subsistence activities and lifestyles due to the changes in the economic characteristics of the region [14, 34, 39]. Still, despite the demographic and economic distinctions between Aracampina and Santana, their patterns of growth and nutrition are generally better than Caxiuanã. However, the better health status of Santana cannot be attributed solely to its geographic location. Overall, the results show that the floodplain groups studied are healthier than the upland group in some aspects, with the reverse being true for others. Access to more cosmopolitan lifestyles is higher among floodplain populations, but Caxiuanã experiences less seasonal influences on health, than Aracampina or Santana.

Conclusions

This is likely one of the first studies combining such a diversity of Amazonian populations and ecosystems analyzed in both seasons of the year. It is clear that both the ecological setting and the marked seasons of the year in the region have a profound impact on the lives and the health of local residents.

In general, the hypothesis presented at the outset is not supported by the data. Many children from all three groups have low weight-for-height, weight-for-age, and height-for-age Z scores when compared to international reference data. However, children from Santana generally are taller and heavier than children from Aracampina and Caxiuanã, respectively. The Santana group also has fewer children with chronic and acute undernutrition during both the dry and the wet seasons. When the two more traditional

populations are compared, Aracampina children are generally taller and heavier than Caxiuanã children, even though these differences are not statistically significant. For Z scores and absolute values of height and weight the children from the more traditional population are smaller and lighter than those in the more westernized groups.

Overall, children of all three groups present weights and heights well below the 50th percentile for same-age children in the NCHS/WHO reference. Apparently, children residing where more traditional subsistence activities are practiced do not receive adequate quality and quantity of nutrients for ideal growth, lagging behind children from the more westernized populations. Generally, the findings suggest an ameliorating effect of westernization, and a secondary, more subtle, effect of the floodplain environment on health and growth. Both growth and health result from complex interactions between biotic and abiotic, cultural and environmental factors, the effects of which are difficult to disentangle. Because these three populations live in different environments and are subject to varying ecological, economic, and social constraints, only longer-term studies will establish more precisely which factors most influence growth within each group.

Although this study contributes to improve our knowledge of growth and health of Caboclo populations, more research is necessary to produce a clearer picture of interactions between environment and health in Amazonian rural populations.

The results presented in this paper have been made available to local and federal governments and to NGOs. We hope this information will help in the development of more efficient policies aimed at improving the health and well-being of the participant populations.

Acknowledgment This research could not have been completed without the collaboration of many institutions and colleagues. First, thanks are due to the communities of Caxiuanã, Santana, and Aracampina for their warm reception and voluntary participation in this research. Thanks to the Brazilian National Council on Scientific and Technological Development (CNPq) for a Doctoral Fellowship to HPS, to the Museu Paraense Emílio Goeldi (MPEG), the Brazilian Institute of the Environment and Natural Resources (IBAMA) in Breves, and the Projeto Várzea/UFGA/IPAM, for their financial and logistic support. HPS thanks specially the Department of Anthropology of The Ohio State University for support during his graduate studies. Thanks are also due to David McGrath, Rui Murrieta, Pedro Lisboa, and Iranildo Oliveira for their friendship and support during field work, and to the field team (Hilton M. Jr., Perpétuo Socorro, André Ribeiro, and Eldson “Cuminho”) for their dedication under the most adverse field conditions.

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